



EM&V Report for the Duke Energy Multifamily Energy Efficiency Program

Prepared for:

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EM&V Report for the Duke Energy
Multifamily Energy Efficiency Program

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1. EVALUATION SUMMARY

1.1 Program Summary

Duke Energy's Multifamily Energy Efficiency Program provides energy efficient equipment to multifamily housing properties at no cost to the property managers or tenant end-users. The program is delivered through coordination with property managers and owners. Tenants are provided with notice and informational materials to inform them of the program and potential for reduction in their energy bills. The program consists of lighting and water measures.

- **Lighting measures:** Compact fluorescent light (CFL) bulbs installed in permanent fixtures
- **Water measures:** Bathroom and kitchen faucet aerators, water-saving showerheads, hot water pipe wrap

For this evaluation cycle, Navigant assessed the following:

Duke Energy Progress: lighting and water measures installed between 1/1/15 and 2/29/16
Duke Energy Carolinas: lighting measures installed between 1/1/14 and 2/29/16¹

Franklin Energy is the implementation contractor for the program. Customers (i.e., property managers) have the option to choose self-installation or direct installation through Franklin Energy. Duke Energy informed Navigant that most customers choose the direct install route by Franklin Energy. Duke Energy also informed Navigant that third-party quality control inspections are completed on 20 percent of properties in any given month. Within a selected property, the quantity of units to inspect is based on property size as defined by the number of housing units.

1.2 Evaluation Objectives and Program-Level Findings

Duke Energy selected Navigant to provide independent Evaluation, Measurement, and Verification (EM&V) for the Multifamily Energy Efficiency Program in the Duke Energy Progress (DEP) and Duke Energy Carolinas (DEC) jurisdictions. EM&V is a term used to describe the process of evaluating a program to assess the impacts as well as the program structure and delivery. For this EM&V effort, the evaluation approach and objectives can be described as follows:

- **Impact evaluation:** To quantify the net and gross energy and coincident demand savings associated with program activity at both the measure level and program level
- **Process evaluation:** To assess program delivery and customer satisfaction

By performing both components of the EM&V effort, Navigant is able to provide Duke Energy with verified energy and demand impacts, as well as a set of recommendations that are intended to aid Duke Energy with improving or maintaining the satisfaction with program delivery while meeting energy and demand reduction targets in a cost-effective manner.

¹ Navigant completed an evaluation report in November of 2015 for water measures in DEC.



Overall, Navigant found that the Multifamily Energy Efficiency Program is being delivered effectively, customer satisfaction is generally favorable, and the reported measure installations are accurate.

For the evaluation period covered by this report, there were a total of 26,492 housing units at 262 participating properties managed by 85 different property management companies in the DEP jurisdiction. There were 21,937 housing units at 210 properties managed by 99 different property management companies in the DEC jurisdiction. The program-level evaluation findings are presented in Table 1 through Table 4. For the DEP jurisdiction, Navigant found the realization rate for gross energy savings to be 94 percent, meaning that total verified gross energy savings were found to be lower than claimed in the tracking database provided by Duke Energy. For DEC, the realization rate for gross energy savings was 66 percent. Navigant found the net-to-gross (NTG) ratio to be 0.94, meaning that for every 100 kWh of reported energy savings, 94 kWh can be attributed directly to the program. These findings will be discussed in greater detail throughout this report.

Table 1. Program Claimed and Evaluated Gross Energy Impacts

	Claimed	Evaluated	Realization Rate
DEP Gross Energy Impacts (MWh)	21,133	19,939	94%
DEC Gross Energy Impacts (MWh)	7,299	4,807	66%

Source: Navigant analysis, totals subject to rounding.

Table 2. Program Claimed and Evaluated Gross Peak Demand Impacts

	Claimed	Evaluated	Realization Rate
DEP Gross Summer Peak Demand Impacts (MW)	1.99	2.35	118%
DEP Gross Winter Peak Demand Impacts (MW)	3.32	3.97	120%
DEC Gross Summer Peak Demand Impacts (MW)	0.68	0.71	104%
DEC Gross Winter Peak Demand Impacts (MW)	0.68	0.90	132%

Source: Navigant analysis, totals subject to rounding.

Table 3. Program Net Energy Impacts

	MWh
DEP Net Energy Impacts	18,836
DEC Net Energy Impacts	4,541

Source: Navigant analysis, totals subject to rounding.

Table 4. Program Net Peak Demand Impacts

	MW
DEP Net Summer Peak Demand Impacts	2.22
DEP Net Winter Peak Demand Impacts	3.75
DEC Net Summer Peak Demand Impacts	0.67



DEC Net Winter Peak Demand Impacts 0.85

Source: Navigant analysis, totals subject to rounding.

1.3 Evaluation Parameters and Sample Period

To accomplish the evaluation objectives, Navigant performed an engineering review of measure savings algorithms, field verification to assess installed quantities and characteristics, as well as surveys with tenants and property managers to assess satisfaction and decision-making processes. The evaluated parameters are summarized in Table 5. For field verification, the expected sampling confidence and precision was 90 percent \pm 10 percent, and the achieved was 90 percent \pm 9 percent.

Table 5. Evaluated Parameters

Evaluated Parameter	Description	Details
Efficiency Characteristics	Inputs and assumptions used to estimate energy and demand savings	<ol style="list-style-type: none"> 1. CFL wattage 2. CFL operating hours 3. Aerator flow rates (gpm) 4. Showerhead flow rates (gpm) 5. Water temperature (F) 6. Pipe wrap length (ft) 7. Baseline characteristics
In-Service Rates	The percentage of program measures in use as compared to reported	<ol style="list-style-type: none"> 1. CFL, aerator, and showerhead quantities 2. Pipe wrap length
Satisfaction	Customer satisfaction	<ol style="list-style-type: none"> 1. Satisfaction with program 2. Satisfaction with contractor 3. Satisfaction with program measures
Free Ridership	Fraction of reported savings that would have occurred anyway, even in the absence of the program	
Spillover	Additional, non-reported savings that occurred as a result of participation in the program	

This evaluation covers program participation from January 1, 2015 through February 29, 2016 in DEP, and from January 1, 2014 through February 29, 2016 in DEC. Table 6 shows the start and end dates of Navigant's sample period for evaluation activities.

Table 6. Sample Period Start and End Dates

Activity	Start Date	End Date
Field Verification	April 4, 2016	April 15, 2016
Tenant Phone Surveys	April 21, 2016	April 30, 2016
Property Manager Interviews	April 30, 2016	May 18, 2016



1.4 Evaluation Recommendations

Navigant developed a series of recommendations during the EM&V effort. These recommendations are intended to assist Duke Energy with enhancing the program delivery and customer experience, as well as to support future EM&V activities and possibly increase program impacts. Further explanation for each recommendation can be found later in this report.

1. Navigant recommends that Duke Energy should adopt the ex post, per-unit energy and demand impacts from this evaluation and use them going forward (with the possible exception of making an appropriate adjustment for the lighting measure baseline as discussed in Section 4 of this report).
2. Navigant recommends that no more than the first three feet of cold water inlet pipes be insulated for the water heater pipe wrap measure.
3. Duke Energy should consider adding LEDs to the program.



2. PROGRAM DESCRIPTION

2.1 Design

The Multifamily Energy Efficiency Program is designed to provide energy efficiency to a sector that is often underserved or difficult to reach via traditional, incentive-based energy efficiency programs. This market can be difficult to penetrate because multifamily housing units are often tenant-occupied rather than owner-occupied, meaning that the benefits of participation may be realized by the tenant whereas the incremental costs of participating in the program are absorbed by the owner.

Duke Energy's Multifamily Energy Efficiency Program provides energy efficient equipment to multifamily housing properties at no cost to the property managers or tenant end-users. The program is delivered through coordination with property managers and owners. Tenants are provided with notice and informational materials to inform them of the program and potential for reduction in their energy bills. The program consists of lighting and water measures.

- **Lighting measures:** Compact fluorescent light (CFL) bulbs installed in permanent fixtures
- **Water measures:** Bathroom and kitchen faucet aerators, water-saving showerheads, hot water pipe wrap

2.2 Implementation

Franklin Energy is the implementation contractor for the program. To recruit participants, Franklin Energy conducts onsite visits, in combination with internet searches, and SalesGenie² lists, to identify properties, property managers, or property management companies that it believes are likely to participate. Franklin Energy then sends an outreach team of energy advisors to coordinate with property managers and explain the program delivery and benefits. This is considered an Energy Assessment. This is also an opportunity for energy advisors to determine the type of measures along with associated quantities that can be installed. One potential delay in committing to the program is the need for the property manager to get approval to participate from their corporate office.

Once a property has been fully assessed and a service agreement has been signed, the project is handed over to a different group at Franklin Energy to schedule the installations. The installation crew performs the work as scheduled, while displaying Duke Energy branded clothing, badges, and vehicle decals as directed. The installation crews record the quantities and locations of installed measures for each housing unit via a tablet device, which are eventually entered into a tracking database.

When energy efficient program measures are installed, Franklin Energy removes the existing or baseline equipment and generally disposes of it onsite. If the property management previously requested to keep the existing equipment, Franklin Energy will package it up and leave it behind with property management or maintenance personnel. In general, Franklin Energy does not record specific information about the

² SalesGenie is a business and consumer lead generation tool that sales and marketing professionals can use to search for targeted [leads](#), get contact names and phone numbers, and view detailed information. The tool also provides marketing and data solutions designed to help businesses reach their intended audiences more effectively.



efficiency characteristics of the equipment being removed, although Franklin Energy indicated they are experimenting with the idea of doing so.³

There can be logistical complications associated with performing these types of retrofits at multifamily housing properties. Franklin Energy indicated that some units may be skipped at a property due to safety issues, lack of access to equipment, pet barriers, or refusal from tenants.

Franklin Energy indicated that they have internal and external forms of quality control (QC) to ensure consistent measure installation. On the internal side, a Franklin Energy supervisor may accompany installation crews to ensure quality work. On the external side, a third-party inspector, High Performance Building Solutions, conducts inspections on a least five percent of participating housing units each year. The QC inspections are required to happen within 22 business days of installation. If a property is selected for a QC inspection, at least 20 percent of the units at the property are targeted for inspection.

During each month of QC inspections, Franklin Energy is provided with a discrepancy report that indicates when measures were missing, installed incorrectly, or if there were missed opportunities. Franklin Energy attempts to address the discrepancies, and subsequently updates the tracking data to reflect the QC findings. The tracking data is ultimately provided to Duke Energy, and subsequently to Navigant for EM&V.

³ During the property assessment phase, Franklin Energy determines that housing units selected for participation contain lower efficiency light bulbs (incandescents) and standard aerators and showerheads.



3. KEY RESEARCH OBJECTIVES

As outlined in the Statement of Work, the key research objectives were to conduct impact and process evaluations, as well as a net-to-gross (NTG) analysis. The evaluation covers both lighting and water measures in DEP, and lighting measures only in DEC.

The primary purpose of the evaluation, measurement, and verification (EM&V) assessment is to estimate net annual energy and demand impacts associated with participation from January 1, 2015 through February 29, 2016 in DEP, and January 1, 2014 through February 29, 2016 for DEC. Secondary objectives include the following:

- Estimate net and gross impacts by measure
- Perform detailed review of deemed savings estimates for each measure, and provide updates if necessary
- Assess the installed quantities and efficiency characteristics of program measures
- Evaluate the strengths and weaknesses of current program processes and customer perceptions of the program offering and delivery
- Recommend improvements to program rules and processes that support greater savings, enhanced cost-effectiveness, and improved customer satisfaction
- Update measure life assumptions, if applicable

Key impact and process research questions to be explored include:

- Is the program achieving targeted energy and demand savings at the measure level?
- How do customers learn about the program, and can participation be increased?
- How is the persistence of savings impacted by participant removal of measures installed through the program?
- Are there opportunities for additional measure offerings through the program?
- Provide the effect on baseline lamp wattage from EISA, including some discussion on the projected degradation of baseline lamp wattage in future years.



4. IMPACT EVALUATION

4.1 Impact Results

Figure 1 shows the program-level results for gross energy savings. Table 7 shows a more complete list of program-level findings. The evaluation team calculated the results in Table 7 by multiplying the measure quantities found in the tracking database by the verified energy and demand savings estimated during the EM&V process for each measure. The net impacts were found by multiplying the gross impacts by the NTG ratio of 0.94. The NTG methodology and results are discussed in detail in Section 5 of this report.

Figure 1. Reported and Verified Program-Level Impacts

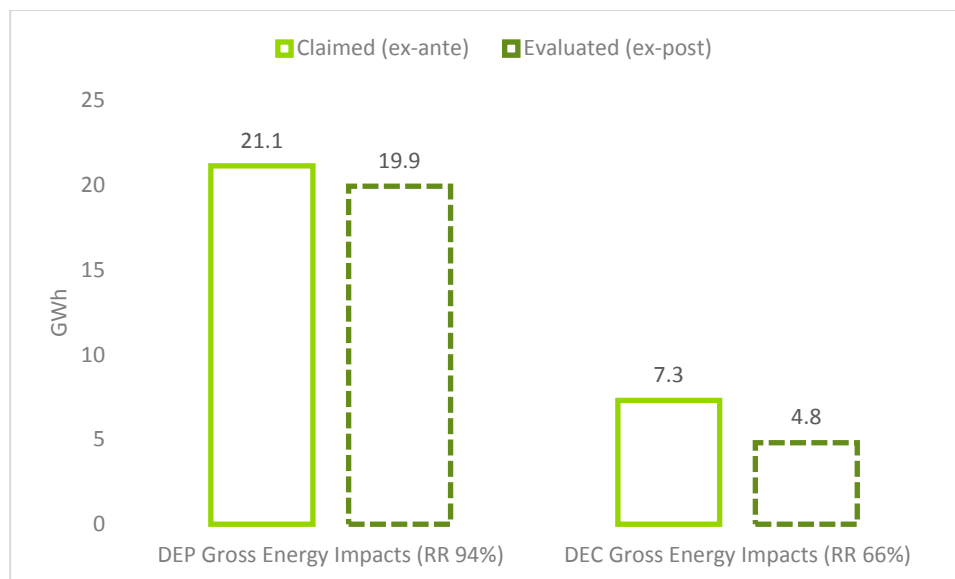


Table 7. Summary of Program Impacts

	Energy (MWh)	Summer Coincident Demand (MW)	Winter Coincident Demand (MW)
DEP Verified Gross Impacts	19,939	2.35	3.97
DEP Verified Net Impacts	18,836	2.22	3.75
DEC Verified Gross Impacts	4,807	0.71	0.90
DEC Verified Net Impacts	4,541	0.67	0.85

Source: Navigant analysis

A summary of each measure's contribution to program savings and realization rate between reported savings and verified savings is shown in Table 8 for DEP, and Table 9 for DEC. Compact Fluorescent Light (CFL) bulbs account for just under half of the energy savings for DEP. By dividing the total verified



savings by the total reported savings in the tracking data in Table 8, Navigant calculates a gross realization rate of 94 percent for energy savings at the program level for DEP. The corresponding realization rate for DEC is 66 percent, as shown in Table 9.

Table 8. Distribution of Program Energy Savings by Measure (DEP)

Measure	Measure Count from Tracking Data	Total Ex Ante Savings from Tracking Data (MWh)	Share of Total Savings from Tracking Data	Total Verified Ex Post Gross Savings (MWh)	Realization Rate
CFLs	238,783	9,718	46%	6,400	66%
Bathroom Faucet Aerators	28,710	1,239	6%	1,135	92%
Kitchen Faucet Aerators	18,862	1,715	8%	1,630	95%
Showerheads	24,743	5,741	27%	5,859	102%
Pipe Wrap (ft)	73,338	2,720	13%	4,916	181%
Total	384,436	21,133	100%	19,939	94%

Source: Navigant analysis

Table 9. Distribution of Program Energy Savings by Measure (DEC)

Measure	Measure Count from Tracking Data	Total Ex Ante Savings from Tracking Data (MWh)	Share of Total Savings from Tracking Data	Total Verified Ex Post Gross Savings (MWh)	Realization Rate
CFLs	179,338	7,299	100%	4,807	66%

Source: Navigant analysis

The realization rate for summer coincident demand is 118 percent at the program level for DEP, as shown in Table 10. The realization rate for summer coincident demand is 104 percent at the program level for DEC, as shown in Table 11. The realization rate for winter coincident demand is 120 percent for DEP and 132 percent for DEC, as shown in Table 12 and Table 13, respectively. These realization rates include adjustments to the estimated savings for each measure which will be discussed during the remainder of this report. On a measure level, the largest adjustments were made to the energy savings for bathroom faucet aerators due to the in-service rates found during field verification.



Table 10. Distribution of Summer Coincident Demand Savings by Measure (DEP)

Measure	Total Savings from Tracking Data (MW)	Share of Total Savings from Tracking Data	Total Verified Ex Post Gross Savings (MW)	Realization Rate
CFLs	0.907	46%	0.941	104%
Bathroom Faucet Aerators	0.163	8%	0.149	92%
Kitchen Faucet Aerators	0.226	11%	0.214	95%
Showerheads	0.472	24%	0.481	102%
Pipe Wrap (ft)	0.217	11%	0.561	258%
Total	1.99	100%	2.35	118%

Source: Navigant analysis

Table 11. Distribution of Summer Coincident Demand Savings by Measure (DEC)

Measure	Total Savings from Tracking Data (MW)	Share of Total Savings from Tracking Data	Total Verified Ex Post Gross Savings (MW)	Realization Rate
CFLs	0.681	100%	0.707	104%



Table 12. Distribution of Winter Coincident Demand Savings by Measure (DEP)

Measure	Total Savings from Tracking Data (MW)	Share of Total Savings from Tracking Data	Total Verified Ex Post Gross Savings (MW)	Realization Rate
CFLs	0.907	27%	1.199	132%
Bathroom Faucet Aerators	0.143	4%	0.131	92%
Kitchen Faucet Aerators	0.197	6%	0.187	95%
Showerheads	1.856	56%	1.893	102%
Pipe Wrap (ft)	0.217	7%	0.561	258%
Total	3.32	100%	3.97	120%

Source: Navigant analysis

Table 13. Distribution of Winter Coincident Demand Savings by Measure (DEC)

Measure	Total Savings from Tracking Data (MW)	Share of Total Savings from Tracking Data	Total Verified Ex Post Gross Savings (MW)	Realization Rate
CFLs	0.681	100%	0.901	132%

Source: Navigant analysis

4.2 Impact Evaluation Methodology

Navigant's methodology for evaluating the gross and net energy and demand impacts of the program included the following components:

1. Detailed review of deemed savings estimates including: engineering algorithms, key input parameters, and supporting assumptions.
2. Onsite field verification to assess measure characteristics and in-service rates (ISRs)
3. Net-to-gross (NTG) analysis
4. Incorporating supplemental impact findings from tenant surveys

4.2.1 Detailed Review of Ex Ante Deemed Savings

Navigant reviewed the ex-ante savings and supporting documentation used to estimate ex ante program impacts. For the compact fluorescent lighting measure in both DEP and DEC, Navigant believes the



deemed savings are well-documented in the previous EM&V report and that the algorithms and assumptions used to estimate savings are reasonable.⁴

The deemed savings for the 13 watt CFLs are shown in Table 14 below. The baseline lamp is assumed to be a 60 watt incandescent.

Table 14. Ex Ante Savings and Parameters for CFLs

Program measure	kWh savings	Non-coincident kW savings	Coincident kW savings	Coincidence factor	Average baseline wattage	EE wattage	Average daily hours of use
13 watt CFL	40.7	0.0469	0.0038	0.081	55.33	13	2.89

Navigant was able to trace all of these findings to the previous EM&V report provided by Duke Energy. The impacts were calculated using the following algorithms:

Equation 1. Energy Savings Algorithm for CFLs

$$kWh\ savings = ISR \times \left[\frac{(Watts_{base} \times HOU_{base}) - (Watts_{EE} \times HOU_{EE})}{1000} \right] \times 365 \times HVAC_C$$

Equation 2. Coincident Demand Savings Algorithm for CFLs

$$kW\ savings^5 = ISR \times \left[\frac{Watts_{base} - Watts_{EE}}{1000} \right] \times CF \times (1 + HVAC_d)$$

Where the parameters are defined as:

ISR = in-service rate

Watts_{base} = wattage of baseline lamp removed

Watts_{EE} = wattage of CFL lamp installed

HOU_{base} = daily operating hours of baseline lamp removed

HOU_{EE} = daily operating hours of CFL lamp installed

HVAC_C = HVAC interaction factor for energy

HVAC_D = HVAC interaction factor for demand

CF = coincidence factor

⁴ *Process and Impact Evaluation of Duke Energy's Residential Smart Saver: Property Manager CFLs in the Carolinas*, TecMarket Works, 2013.

⁵ To calculate winter coincident demand savings, the HVAC interaction factor, HVAC_d, is subtracted instead of added. This conservative assumption accounts for a mix participants who will have electric heat pumps for heating, as well as those who may use auxiliary electric heating to supplement gas during winter coincident peak periods.



For water measures, the deemed savings for DEP were based on Navigant's recent EM&V of water measures in the DEC, so little review was needed.⁶

4.2.2 Onsite Field Verification

Navigant performed onsite field verification at 123 housing units across 16 properties. Field verification efforts were designed to assess the measure characteristics as reported in the tracking data and to assess measure parameters that can be used to verify inputs and assumptions used to estimate energy and demand savings for individual measures. Table 15 shows a summary of the parameters assessed by Navigant during field verification, and Table 16 shows the field verification sample.

Table 15. Parameters Evaluated During Field Verification

	CFLs	Faucet Aerators	Water-saving Showerheads	Hot Water Pipe Wrap
Installed quantity	x	x	x	x
Installed wattage	x			
Flow rates (gpm)		x	x	
Water heating system characteristics		x	x	x
Water Temperatures		x	x	x
Pipe length				x
Measure location	x	x	x	x
Baseline information (where available)	x	x	x	x

Table 16. Field Verification Sample

Program Measure	Number of Housing Units in Sample ^a	Number of Measures Reported in Sample
CFLs	123	1,181
Bathroom Faucet Aerators	73	97
Kitchen Faucet Aerators	76	76
Showerheads	76	91
Pipe Wrap	31	162 ft

a. Totals exceed 123 because many sites had multiple measures

Source: Navigant analysis

A summary of findings from field verification is included in Section 4.3.

⁶ Please refer to Navigant's report, titled "Multifamily Energy Efficiency Program, Evaluation, Measurement, and Verification for Duke Energy Carolinas", dated 11-3-15 for more information.



4.2.3 Tenant Surveys

Navigant incorporated supplemental findings from 150 tenant phone surveys to inform the impact analysis where applicable. The findings from the tenant surveys will be addressed later in this report.

4.3 Impact Evaluation Findings

The impact evaluation findings for lighting measures and water measures are discussed separately.

4.3.1 Compact Fluorescent Light Bulbs

Table 17 shows a summary of Navigant's ex-post, verified findings for CFLs. The energy savings per bulb decreased from the 40.7 kWh provided in the deemed savings to 26.8 kWh. To calculate verified energy and demand impacts, Navigant assessed the parameters that were used in the algorithms to estimate ex-ante savings. Table 18 lists all parameters used to calculate ex-post savings.

Table 17. Summary of CFL findings

	Ex-Post	Ex-Ante
In-Service Rate ¹	84.6%	94.7%
Daily Operating Hours	1.93	2.89
Gross Energy Savings Per Bulb (kWh)	26.8	40.7
Gross Summer Coincident Demand Savings Per Bulb (kW)	0.0039	0.0038
Gross Winter Coincident Demand Savings Per Bulb (kW)	0.0050	N/A

1. Navigant did not account for vacant housing units, so the actual number of CFLs in use may be lower.

Source: Navigant analysis

Table 18. Calculation parameters for ex post CFL impacts

Program measure	ISR	Average baseline wattage	EE wattage	Average daily hours of use for baseline lamps ^a	Average daily hours of use for CFLs ^a	Summer coincidence factor	Winter coincidence factor	Energy HVAC interaction factor ^b	Demand HVAC interaction factor ^{b,c}
13 watt CFL	84.6%	60	13	1.93	1.93	0.082	0.32 ^d	0.96	0.21
<p>a. Includes self-report bias correction factor from TecMarket Works and Building Metrics. "Duke Energy Residential Smart Saver® CFL Program in North Carolina and South Carolina". February 15, 2011. Pg. 35.</p> <p>b. Sourced from 2016 Mid-Atlantic TRM</p> <p>c. The demand HVAC interaction factor is added for summer coincident demand impacts, and subtracted for winter. Navigant also adjusted the interaction factor for winter demand to account for 50% of participants having gas heating per the 2013 Duke Energy Residential Appliance Saturation Survey.</p> <p>d. Source: <i>Coincidence Factor Study, Residential and Commercial & Industrial Lighting Measures</i>, prepared for: New England State Program Working Group</p>									



4.3.1.1 In-Service Rate

At the 123 housing units inspected by Navigant that had CFLs, there were a total of 1,181 reported program CFLs in the tracking database. During the inspections, Navigant found 844 CFLs. Additionally, during phone surveys with tenants, Navigant interviewed customers representing an additional 1,186 CFLs. Thirteen of the phone survey respondents indicated they had removed a total of 41 CFLs. The predominant reason for removing CFLs was burnout. Navigant used a weighted average to combine the ISR from field verification with the ISR from phone surveys to calculate a final ISR.⁷

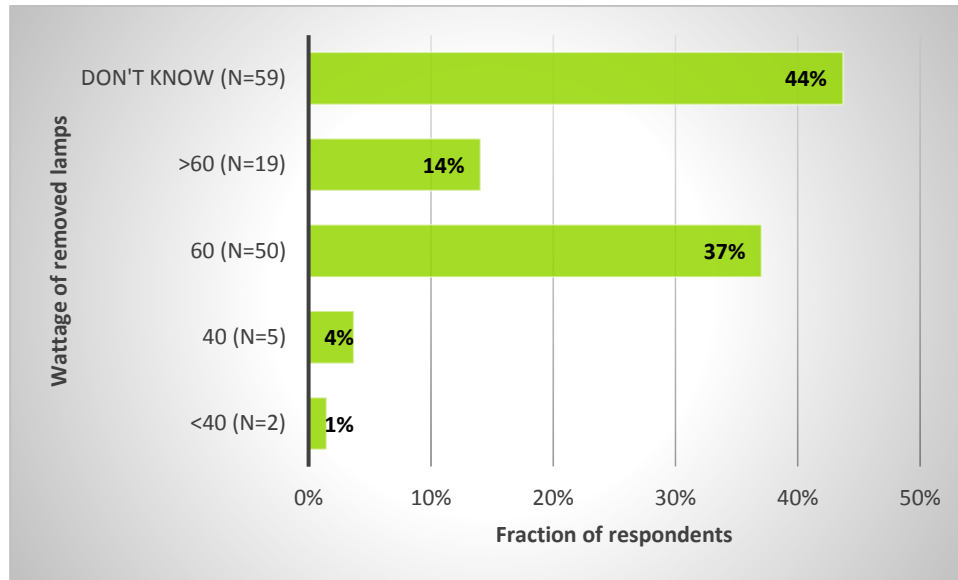
4.3.1.2 Wattage

Navigant assessed the wattage of CFLs inspected during the onsite verification and found them to be 13 watts as reported. However, there is potential uncertainty in the wattages of lamps removed during the retrofit process, or at least whether that wattage should be the baseline going forward. The time period covered by this evaluation is January of 2014 through February of 2016. The Energy Independence and Security Act (EISA) of 2007 established that as of January 1st, 2014, 60 watt incandescent bulbs could no longer be manufactured or imported. The new, EISA compliant wattage was 43. However, Navigant's experience has shown that there was considerable lag between the EISA compliance schedule and actual market activity, and potential back stocking of incandescents by multifamily maintenance staff. Because Duke Energy's Multifamily Energy Efficiency Program is a retrofit program (rather than replace on burnout), it is important to consider the actual characteristics of the lamps removed because they likely had remaining useful life. Franklin Energy has indicated that they only remove incandescent lamps during the retrofit process.

Figure 2 shows the results of customer self-reporting from tenant phone surveys with regards to the wattage of lamps removed during participation in the program. It can be seen that a large number of respondents were not sure, but more than half (51 percent) of respondents indicated that the lamps were 60 watts or higher. Additionally, during Navigant's field verification efforts, seven tenants were able to recall the lamps removed, and all seven indicated they were 60 watt incandescents. High rates of tenant turnover at multifamily housing units could explain why so many customers did not know what type of lamps were removed.

⁷ The weighted results reflect a total of 1,989 verified CFLs out of a sample of 2,367. Navigant used the same approach to calculate ISRs during our 2015 evaluation of this program in DEC. We believe that combining the results from field and phone verification effectively increases the sample size, and helps to control for the extended time period covered by this evaluation by incorporating participant input and field observations.

Figure 2. Customer self-reporting of wattage of lamps removed



Given that the period of time covered by this evaluation coincides with important EISA compliance dates that may have experienced a lag in market uptake, along with the results shown in Figure 2, Navigant believes that a baseline wattage assumption of 60 watts was appropriate for this evaluation cycle. However, as will be discussed later in this report, Navigant suggests further research be conducted to understand the lighting baseline for future evaluation cycles.

4.3.1.3 HVAC Interaction and Coincidence Factors

Navigant reviewed the ex-ante assumptions for HVAC interaction factors and summer coincidence factors and chose to replace them with updated values from the 2016 Mid-Atlantic TRM. For a winter coincidence factor, Navigant used a secondary literature source.⁸

4.3.1.4 Lighting Hours of Use

The hours of use for CFLs are an important parameter input to the energy savings algorithm, however the scope and budget of this evaluation did not support a full metering study to quantify operation hours. Navigant assessed the lighting operation hours via the following methods:

1. Collected self-report data from program participants during tenant phone surveys
2. Performed extensive review of the previous estimates for deemed savings
3. Performed a literature review to assess estimates from secondary sources

⁸ RLW Coincidence Factor Study for New England State Program Working Group, https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/National%20Grid/116_RLW_CF%20Res%20C&I%20ltg.pdf



4. Applied self-report bias correction factor from previous study completed for Duke Energy

Navigant collected self-reported hours of use estimates from participants during the tenant phone surveys with 150 participants. The average self-reported estimate was 2.64 hours per day. Navigant recognizes that significant uncertainty exists in customer ability to estimate hours of use. For that reason, the evaluation team compared the self-report estimate of 2.64 with other sources.

Table 19 shows a comparison of estimated CFL operating hours from several sources. Navigant applied a self-reporting bias correction factor of 0.73 (a 27 percent reduction) to the self-reported operating hours, for a final value of 1.93 hours per day. The bias correction factor was sourced from a previous study completed for Duke Energy.⁹

Table 19. Comparison of CFL Operating Hours

Estimated Daily CFL Usage Hours	Method	Source
2.89	Metering Study	TecMarket Works, previous EM&V study for Property Manager CFL Program for Duke Energy ¹⁰
2.21	Metering study	Navigant metering study for similar multifamily program in Southwestern U.S.
1.5-1.6	Meta data analysis	U.S. Department of Energy <i>Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates</i> (2012) ¹¹

Source: Navigant analysis

4.3.1.5 Effect of Baseline Wattage Requirements for EISA

It is important to address the topic of CFL baseline in more detail. The Energy Independence and Security Act (EISA) was enacted to increase the availability of reduced wattage lighting options, and hence shift the lighting market toward higher efficiency. In theory, this would eventually cause the program CFL baseline to eventually shift to a lower wattage as 60 watt incandescents become less-prominent. There is still uncertainty around what the exact baseline is in Duke Energy's service territories.

Navigant believes that EISA standards should be applied to new construction applications or replace-on-burnout scenarios. However, the Multifamily Energy Efficiency Program is primarily a direct install retrofit program targeting existing homes where the existing lamps likely have remaining useful life. The program implementer requires that all lamps being removed are incandescents. Furthermore, some program participants have reported that the lamps removed were higher than 60 watts. Due to the

⁹ TecMarket Works and Building Metrics. "Duke Energy Residential Smart Saver® CFL Program in North Carolina and South Carolina". February 15, 2011. Pg. 35.

¹⁰ *Process and Impact Evaluation of Duke Energy's Residential Smart Saver: Property Manager CFLs in the Carolinas*, TecMarket Works, 2013.

¹¹ http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf



changing market for residential lighting, Navigant suggests that further research be conducted in future evaluation years to assess the baseline.

4.3.2 Water Flow Regulation Measures

For field verification of program water measures, Navigant collected information to validate the efficiency characteristics of the equipment. This included verifying the reported number of measures and measuring actual flow rates of the retrofit equipment.

4.3.2.1 In-Service Rate

The ISRs for water measures are shown in Table 20. These were calculated using a weighted average of results from the onsite field verification inspections and the tenant phone surveys.

Table 20. In-Service Rates for Water Measures

Measure	ISR
Kitchen aerators	94%
Bathroom aerators	92%
Showerheads	95%
Pipe wrap	93%

Source: Navigant analysis

4.3.2.2 Energy Savings

The deemed savings for water measures in DEP are based on a recent EM&V report by Navigant for DEC, which was completed in November of 2015. The evaluation team used a similar approach for DEP, but supplemented or replaced inputs with data gathered during field verification. To calculate verified savings for aerators and showerheads, Navigant used a standard engineering equation taken shown in Equation 3, Equation 4, and Equation 5. Navigant subsequently applied inputs collected during field verification or assumptions as listed below in Table 21. The resulting estimates for impacts of aerators and showerheads are presented in Table 22.

Equation 3. Algorithm for Estimating Energy Savings for Faucet Aerators

kWh savings for faucet aerators

$$= ISR \times \left[\frac{(GPM_{base} - GPM_{low}) \times T_{home/day} \times 365 \frac{days}{yr} \times DF \times (T_{out} - T_{in}) \times 8.3 \frac{Btu}{gal \cdot ^\circ F}}{\#_{faucets} \times 3412 \frac{Btu}{kWh} \times RE} \right]$$

Equation 4. Algorithm for Estimating Energy Savings for Low Flow Showerheads

kWh savings for low flow showerheads

$$= ISR \times \left[\frac{(GPM_{base} - GPM_{low}) \times T_{home/day} \times N_{showers/day} \times 365 \frac{days}{yr} \times (T_{out} - T_{in}) \times 8.3 \frac{Btu}{gal \cdot ^\circ F}}{\#_{showers} \times 3412 \frac{Btu}{kWh} \times RE} \right]$$



Equation 5. Algorithm for Estimating Coincident Demand Savings for Aerators and Showerheads

$$\Delta kW_{peak} = \Delta kWh/yr \times CF/365$$

Table 21. Input Parameters and Assumptions for Aerator Savings Calculations

Input	Definition	Value	Source
ISR	In-service rate	Refer to Table 20	Navigant field verification and phone surveys
GPM _{base}	Baseline flow rate	Aerators 2.2 Shower 2.5	Deemed savings assumptions from Duke Energy
GPM _{low}	Retrofit flow rate	Aerators 1 Shower 1.5	Deemed savings assumptions from Duke Energy ^a
T _{home/day}	Avg hot water use per day per home (minutes)	Kitchen 4.7 Bath 2.4 Shower 8.4	Building America Benchmark
N _{showers/day}	Number of showers per person per day	1	Navigant assumption
DF	Percent of water going down drain	Kitchen 75% Bath 90%	Navigant assumption
T _{out}	Temp of water flowing from faucets (F) Temp of water flowing from showerheads (F)	90 ^b 105	Navigant field verification 2016 Mid-Atlantic TRM
T _{in}	Temp of water entering water heater (F)	66	Navigant field verification
#faucets/showers	Number of faucets in home (used to distribute minutes of use between different faucets)	Kitchen 1 Bathroom 1.33 Shower 1.2	Navigant field verification
RE	Recovery efficiency of water heater	0.98	Ohio TRM
CF (aerators)	Coincidence Factor	Summer 0.048 Winter 0.042	Building America Benchmark
CF (showerheads)	Coincidence Factor	Summer 0.03 Winter 0.118	Building America Benchmark

- a. Navigant measured flow rates during onsite field verification and they were lower than the reported flow rates for the measures installed. However, this was likely due to calcification or water pressure characteristics and suggests that baseline flow rates may also have been lower. Because we did not measure flow rates for baseline units, we chose to use the reported flow rates in both cases.
- b. The actual measured hot water temperature was 109F. For analysis purposes, Navigant assumed that customers use water at a temperature of 90 degrees, or the average of 109F and 70F.



Table 22. Verified Estimates of per Unit Impacts for Aerators and Showerheads¹²

Measure	Annual Energy Savings per Unit (kWh)		Annual Summer Coincident Demand Savings per Unit (kW)		Annual Winter Coincident Demand Savings per Unit (kW)	
	Ex Post	Ex Ante	Ex Post	Ex Ante	Ex Post	Ex Ante
Kitchen aerator (1.0 GPM)	86	91	0.0114	0.0120	0.0099	0.010
Bathroom aerator (1.0 GPM)	40	43	0.0052	0.006	0.0045	0.005
Low flow showerhead (1.5 GPM)	237	232	0.0195	0.0190	0.0765	0.0750

Source: Navigant analysis

4.3.3 Water Heater Pipe Wrap

During field verification, Navigant found that some of the water heater pipe wrap was installed on the cold water inlet pipe to the water heater. Industry standards are to install pipe wrap on all hot water pipes, and only the first three feet of the cold water pipe because savings are minimal from insulating cold water pipes.¹³ Therefore, when calculating the ISR, Navigant did not count savings from pipe wrap of greater than three feet installed on cold water pipes.

To estimate impacts from the pipe wrap measure, Navigant used algorithms from the 2016 Mid-Atlantic TRM shown in Equation 6 and Equation 7 below.¹⁴ The ex-post impacts are shown in Table 23.

Equation 6. Energy savings for water heater pipe wrap

$$\Delta kWh = \left(\frac{1}{R_e} - \frac{1}{R_n} \right) \times (L \times C) \times \Delta T \times 8760 \div nDHW \div 3413$$

Equation 7. Demand savings from water heater pipe wrap

$$\Delta kW = \Delta kWh \div 8760$$

The following list defines the parameters used in the equations above:

- R_e = R-value of existing, uninsulated pipe ($R = 1$)
- R_n = insulation R-value of pipe after retrofit ($R = 2.5$)
- L = length of pipe (per foot)
- C = circumference of pipe (Navigant assumed average of 0.5" and 0.75" diameter pipe)
- ΔT = temperature difference between water in pipe and ambient air (65F)
- $nDHW$ = heat recovery efficiency (0.98)
- 3413 = conversion from Btu to kWh

¹² The program offers aerators and showerheads at other flow rates. However, the tracking data indicated that 100 percent of the water measures installed during the period covered by this evaluation cycle were the flow rates shown in Table 22, so a verified savings are shown here for only those measures. A full list of savings is shown in Section 9

¹³ <http://www.energy.gov/energysaver/projects/savings-project-insulate-hot-water-pipes-energy-savings>

¹⁴ <http://www.neep.org/mid-atlantic-technical-reference-manual-v6>



Table 23. Verified Impacts for Water Heater Pipe Wrap

Measure	Annual Energy Savings per Unit (kWh)	Annual Summer Coincident Demand Savings per Linear Foot (kW)	Annual Winter Coincident Demand Savings per Linear Foot (kW)
Ex Post	67	0.0077	0.0077
Ex Ante	37	0.0030	0.0030

Source: Navigant analysis

4.3.4 Measure Life

Navigant reviewed the measure life assumptions for all program measures and compared them to other sources from secondary literature research. The evaluation team believes all program measure lives are appropriate and not in need of an update.



5. NET-TO-GROSS ANALYSIS

Navigant conducted an NTG analysis to estimate the share of program savings that can be attributed to participation in or influence from the program. Table 24 shows the results of Navigant's NTG analysis. Navigant anticipated low free ridership and spillover given that the program is structured to offer energy efficient equipment at no cost to multifamily housing units, which are typically not owner-occupied. The results shown here are in line with expectations. Navigant chose to present a program-level NTG ratio rather than measure level due to the limited sample size of property managers and the fact that it is difficult to estimate spillover by measure. Navigant believes it is more appropriate to present the NTG ratio in aggregate.

Table 24. NTG Results

Estimated Free Ridership	7.5%
Estimated Spillover	2.0%
Estimated NTG	0.94

Source: Navigant analysis

5.1 Overview of Net-to-Gross Methodology

As indicated in the evaluation plan, Navigant used a survey-based, self-report methodology to estimate free ridership and spillover for the Multifamily Energy Efficiency Program. A self-report approach is outlined in the Universal Methods Protocol (UMP), and Navigant has previously used this method to estimate a NTG ratio for several other Duke Energy programs in the Carolinas. Navigant primarily targeted property managers for the NTG surveys, because they are the decision makers for participation in the program.¹⁵ Navigant also incorporated supplemental data gathered during tenant phone surveys into the analysis.

5.1.1 Definitions of Free Ridership, Spillover, and NTG Ratio

The methodology for assessing the energy savings attributable to a program is based on a NTG ratio. The NTG ratio has two main components: free ridership and spillover.

Free ridership is the share of the gross savings that is due to actions participants would have taken anyway (i.e., actions that were not induced by the program). This is meant to account for naturally occurring adoption of energy efficiency measures. The Multifamily Energy Efficiency Program and most other Duke Energy programs cover a wide range of energy efficiency measures and are designed to advance the overall energy efficiency market. However, it is likely that, for various reasons, some participants would have wanted to install some high-efficiency measures even if they had not participated in the program or been influenced by the program in any way.

¹⁵ Navigant recognizes that some property managers may have been instructed to participate by higher-level decision makers at the corporate level. Although we do not think this was the case very often, we do think that the local property managers were still privy to the decision making process.



Spillover captures program savings that go beyond the measures installed through the program. Also called market effects, the term spillover is often used because it reflects savings that extend beyond the bounds of the program records. Spillover adds to a program's measured savings by incorporating indirect (i.e., non-incentivized) savings and effects that the program has had on the market above and beyond the directly incentivized or directly induced program measures.

The overall NTG ratio accounts for both the net savings at participating projects and spillover savings that result from the program but are not included in the program's accounting of energy savings. When the NTG ratio is multiplied by the estimated gross program savings, the result is an estimate of energy savings that are attributable to the program (i.e., savings that would not have occurred without the program). The NTG formula is shown in Equation 8:

Equation 8. Net-to-Gross Formula

$$NTG = 1 - \text{free ridership} + \text{spillover}$$

The underlying concept inherent in the application of the NTG formula is that only savings caused by the program should be included in the final net program savings estimate but that this estimate should include all savings caused by the program.

5.1.2 Estimating Free Ridership

Data to assess free ridership was gathered through the self-report method using a series of survey questions asked to the property managers at participating properties. The survey assessed free ridership using both direct questions, which aimed to obtain respondent estimates of the appropriate free ridership rate that should be applied to them, and supporting or influencing questions, which could be used to verify whether the direct responses were consistent with participants' views of the program's influence.

Each respondent to the survey provided perspectives on the measures that they had installed through the program. The core set of questions addressed the following three categories:

- **Likelihood:** To estimate the likelihood that they would have incorporated measures "of the same high level of efficiency," if not for the assistance of the program. In cases where respondents indicated that they might have incorporated some but not all of the measures, they were asked to estimate the share of measures that would have been incorporated anyway at high efficiency. This flexibility in how respondents could conceptualize and convey their views on free ridership allowed respondents to give their most informed response, thus improving the accuracy of the free ridership estimates.
- **Prior planning:** To further estimate the probability that a participant would have implemented the measures without the program. Participants were asked the extent to which they had considered installing the energy efficient measure prior to participating in the program. The general approach holds that if customers were not definitively planning to install all of the efficiency measures prior to participation then the program can reasonably be credited with at least a portion of the energy savings resulting from the high-efficiency measures. Strong free ridership is reflected by those participants who indicated they had already allocated funds for the purchase and selected the equipment and an installer.
- **Program importance:** To clarify the role that program components (e.g., information, incentives) played in decision-making and to provide supporting information on free ridership.



Responses to these questions were analyzed for each respondent, not just in aggregate, and were used to identify whether the direct responses on free ridership were consistent with how each respondent rated the influence of the program.

Free ridership scores were calculated for each of the three categories.¹⁶ Navigant then calculated a weighted average from each respondent based on their share of sample energy savings, and divided by 10 to convert the scores into a free ridership percentage. Next, a timing multiplier was applied to the average of the three scores to reflect the fact that respondents indicating that their energy efficiency actions would not have occurred until far into the future may be overestimating their level of free ridership. Participants were asked when they would have installed the equipment without the program. Respondents who indicated that they would not have installed the equipment for at least two years were not considered free riders and received a timing multiplier of 0. If they would have installed at the same time as they did, they received a timing multiplier of 1; within one year, a multiplier of 0.67; and between one and two years, a multiplier of 0.33. Participants were also asked when they learned about the financial incentive; if they learned about it after the equipment was installed then they received a timing multiplier of 1.

5.1.3 Estimating Spillover

The basic method for assessing participant spillover was an approach that asked a set of questions to determine the following:

- **Whether spillover exists at all.** These were yes-or-no questions that asked, for example, whether the respondent incorporated energy efficiency measures or designs that were not recorded in program records and did not receive any rebates from Duke Energy.
- **The savings that could be attributed to the influence of the program.** Participants were asked to list the extra measures they installed, and the evaluation team assigned a savings value. See below for the method of assigning savings.
- **Program attribution.** Estimates were derived from a question asking the program importance on a 0 to 10 scale. Participants were also asked how the program influenced their decisions to incorporate additional energy efficiency measures.

¹⁶ Scores were calculated by the following formulas:

- **Likelihood:** The likelihood score is 0 for those that “definitely would NOT have installed the same energy efficient measure” and 1 for those that “definitely WOULD have installed the same energy efficient measure.” For those that “MAY HAVE installed the same energy efficient measure,” the likelihood score is their answer to the following question: “On a scale of 0 to 10, where 0 is DEFINITELY WOULD NOT have installed and 10 is DEFINITELY WOULD have installed the same energy efficient measure, can you tell me the likelihood that you would have installed the same energy efficient measure?” If more than one measure was installed in the project, then this score was also multiplied by the respondent’s answer to what share they would have done.
- **Prior Planning:** If participants stated they had considered installing the measure prior to program participation, then the prior planning score is the average of their answers to the following two questions: “On a scale of 0 to 10, where 0 means you ‘Had not yet planned for equipment and installation’ and 10 means you ‘Had identified and selected specific equipment and the contractor to install it,’ please tell me how far along your plans were” and “On a scale of 0 to 10, where 0 means ‘Had not yet budgeted or considered payment’ and 10 means ‘Already had sufficient funds budgeted and approved for purchase,’ please tell me how far along your budget had been planned and approved.”
- **Program Importance:** This score was calculated by taking the maximum importance on a 0 to 10 scale of the four program importance questions and subtracting from 10 (i.e., the higher the program importance, the lower the influence on free ridership).



If respondents said no, they did not install additional measures, they were assigned a 0 score for spillover. If they said yes, then Navigant estimated the energy spillover savings on a case-by-case basis. It is important to note that although free ridership questions were only asked of property managers, Navigant surveyed both property managers and tenants for spillover.¹⁷

5.1.4 Combining Results Across Respondents

The evaluation team determined free ridership estimates for each of the following:

- Individual respondents, by evaluating the responses to the relevant questions and applying the rules-based approach discussed above.
- The program as a whole, by taking a weighted average of the individual results based on each respondent's share of reported energy savings.

5.2 Results for Free Ridership, Spillover, and Net-to-Gross

5.2.1 Review of Data Collection Efforts for Attribution Analysis

Surveys were conducted with decision makers to provide the information to estimate free ridership, and thus, NTG ratios. A total of 21 property managers were surveyed. These 21 property managers managed 39 total properties in the program. This sample represents about 10 percent of the total reported energy savings, as shown in Table 25.

Table 25. Property Manager Sample Representation

	Program Total	Sample Total	% of Program
Properties	449	39	9%
CFLs	418,121	39,942	10%
Bathroom faucet aerators	28,710	2,737	10%
Kitchen faucet aerators	18,862	1,948	10%
Showerheads	24,743	1,964	8%
Pipe wrap (ft)	73,338	10,189	14%
Total Energy Savings			10%

Source: Navigant analysis

5.2.2 Free Ridership Results

¹⁷ The reason for not assessing free ridership at the tenant level is because tenants generally participated in the program via their property managers rather than personal choice. It is possible that tenants would have installed the same measures themselves, but Navigant does not believe they should be considered free riders to the program because the timing of those installations would have been difficult to evaluate and tenants would still have the ability to install CFLs in non-retrofitted fixtures. If a tenant already had equivalent measures in place, it is unlikely that the implementer would have replaced them with program measures.



As described above, surveyed participants responded to a series of questions intended to elicit explicit estimates of free ridership, as well as ratings of program influence. Estimates are based on questions regarding the likelihood, scope, and timing of the investments in energy efficiency if the respondent had not participated in the program. For the Multifamily Energy Efficiency Program, free ridership was estimated at 7.5 percent, which is a relatively low value as anticipated by Navigant.

Navigant developed the free ridership estimate presented above based on responses to a variety of questions that related to survey respondents' intentions prior to participating in the program and to the influence of the program itself. Below are summaries by scoring component.

Prior Planning: Fourteen of the respondents did not have any prior plans for installing any of the energy efficient measures. The other seven respondents indicated that they did have plans, but for the most part, their plans were not very far along. These results indicate low free ridership.

Program Importance: Respondents stated that the program was very important in having the measures installed. Several property managers noted that their decision to participate was influenced by helping their tenants save energy and money.

Likelihood: Respondents were asked in the absence of the program, if they would have had at least some of the work done. Twelve respondents stated they "definitely would not have" installed the measures in the absence of the program, and six said they "may have".

Timing: 11 of 21 respondents stated they would have done the installation within two years or less in the absence of the program. The other 10 stated they would have done the installation after two years or never if not for the program. These findings are suggestive of low free ridership.

In summary, respondents indicated that the program was very important in their decisions to have the energy efficient measures installed. Some indicated that they did have some prior plans to install the measures, but their plans were not very far along.

5.2.3 Spillover Results

Three of the 21 surveyed property managers indicated that the program influenced him/her to install additional, non-incentivized energy efficiency measures at the property. The additional measures included LEDs in outdoor or common spaces, attic insulation, and water heater insulation wraps. In addition to the three property managers reporting spillover, eight tenants reported installing a small number of LEDs and other efficient lights after participating in the program.

Navigant estimated spillover from the equipment reported by property managers and tenants by applying simple engineering equations along with the self-reported measure quantities and characteristics. Navigant calculated the total spillover to be 2.0 percent.

5.2.4 NTG Results

The NTG ratio was calculated as written in Equation 9:



Equation 9. Net-to-Gross Ratio

$$NTG = 1 - \text{free ridership} + \text{spillover} = 1 - 0.075 + 0.0197 = 0.9447$$

This suggests that for every one kWh reduced from program measures, about 0.94 kWh of savings can be directly attributed to the program.



6. PROCESS EVALUATION

Navigant conducted a process evaluation of the Multifamily Energy Efficiency Program to assess program delivery and customer satisfaction. The process findings summarized in this section are based on the results of customer surveys with 150 program participants, detailed surveys with 21 property managers representing 39 properties, an interview with the Duke Energy Program Manager, and a high level review of the program documents and functionality. The property manager interviews and tenant surveys were also used to inform the NTG analysis.

6.1 Key Findings

- The program appears to be effectively addressing many key challenges that are inherent to delivering energy efficiency programs to non-owner-occupied multifamily housing facilities.
- Over half of the property managers learned about this program through outreach by a program representative. This onsite marketing approach seems to be a successful way of gaining participants. Most tenants learned of this program through their property managers.
- Property managers indicated they chose to participate in the program to provide a service and save money for their tenants and owners as well as to capitalize on the free installation to save on internal labor costs
- 75 percent of DEP tenants and 83 percent of DEC tenants noticed savings on their energy bills since the installation of the measures.
- 55 percent of tenants stated that the program CFLs were installed in the light fixtures used most in the home. Incandescent bulbs were listed as the most commonly removed type of bulb.
- A majority of program participants were satisfied with the program. On a scale of 0 to 10, where 0 indicates "not satisfied at all" and 10 indicates "extremely satisfied":
 - Over 65 percent of participants indicated 8-10 for satisfaction with the overall program
 - Over 80 percent of participants indicated 8-10 for satisfaction with the installer's quality of work
 - Over 70 percent of participants indicated 8-10 for satisfaction with Duke Energy
- High satisfaction ratings by tenants were often associated with money savings as the primary benefit. Low satisfaction ratings were often associated with complaints about the equipment.
- Satisfaction was higher for CFLs than for showerheads and aerators.
- During the tenant phone surveys, several participants expressed dissatisfaction with the low water pressure in their showers and sinks. Additionally, some property managers indicated that they had received tenant complaints about low water pressure.

6.2 Documentation Review

Navigant requested program documentation and tracking data to conduct a complete review of current processes. The program tracking data was sufficient to identify the measure characteristics and quantities of installed measures for each tenant at the participating properties.



6.3 Property Manager Interviews

The evaluation team conducted interviews with property managers from the participating properties to assess decision-making (which will ultimately feed into the NTG analysis) and overall satisfaction with the program. The evaluation team interviewed twenty-one property managers who were responsible for 39 properties representing over 56,000 measures or 10% of the program measures.

Overall, property managers indicated that their experience with the program was very favorable. Some key findings from the property manager interviews are listed below:

- Property managers expressed high satisfaction with the free program measures and free installation by an external contractor. Property manager's noted the contractor's quality of work as "well done and professional" and "impressive."
- Over 60% of property managers responsible for their energy bills noticed a decrease in the property energy bills since participating in the program.
- Over 95% of property managers are very likely to recommend this program to other property managers. Provided are a subset of property manager responses on how the program influenced their decision to install the energy efficient measures:
 - "The program made it happen, otherwise it never would have."
 - "The program made it easy, so why not do it."
 - "[Duke Energy] did all the work and we just made the appointments available to get the efficient measures installed. Overall the cost and the work was done quickly."
 - "I didn't have to do anything. We just scheduled the appointment and they just came and did the installs."
 - "[I] saw that it would save move – just the electricity costs and everything it just made sense."
- One property's maintenance staff communicated that after 90 days, over 40% of the installed showerheads started leaking due to dirt buildup. The maintenance staff was able to clean the showerheads after discovering the root problem.
- One property's maintenance staff indicated that some tenants are confiscating program lightbulbs, showerheads, and aerators upon apartment turnover.
- A small number of property managers stated that they were not satisfied with the responsiveness of program staff if any rescheduling or additional follow-up work was needed.
- General suggestions for program improvement from property managers and maintenance staff include adding the following measures/material to the program: window weather stripping, outside or porch lights, and a reminder sticker below the thermostat to display a suggested air conditioner temperature.

6.4 Overall Marketing and Outreach

Customer outreach is a key driver to program participation. Navigant recognizes the importance of marketing and outreach with regards to continued participation and satisfaction, so several questions in the tenant survey and property manager interviews were included to address this.



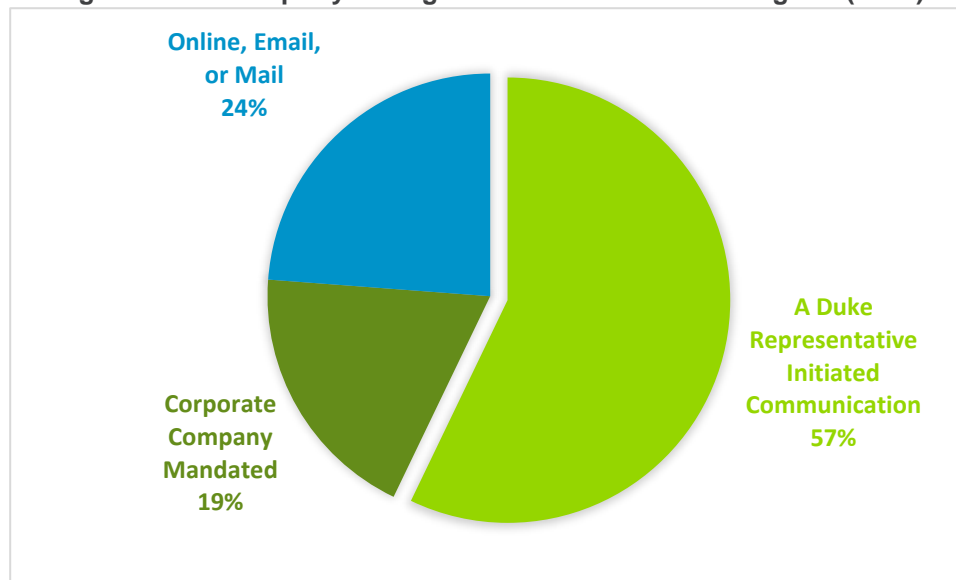
Table 26 and Figure 3 show how tenants and property managers learned about the program, respectively. Tenant participants were asked to indicate all of the sources through which they learned about the program, and about 70 percent indicated they had learned about the program through property managers as would be expected given the program model. Tenants also indicated having received notice via a Duke Energy mailing or bill stuffer. Property managers indicated that they were approached in-person by a program representative, or received a mail or email with program details.

Table 26. How Tenants Learned About the Program

How Tenants Learned About the Program (n=150)	
Through property manager	70%
Duke Energy mailing or bill stuffer	13%
Duke Energy website	5%
Through family, friend or neighbor	4%
Marketing by trade ally, vendor or contractor	1%
Duke Energy email	1%
Don't Know	6%

Source: Navigant analysis

Figure 3. How Property Managers Learned About the Program (n=21)



Source: Navigant analysis

6.5 Tenant Surveys

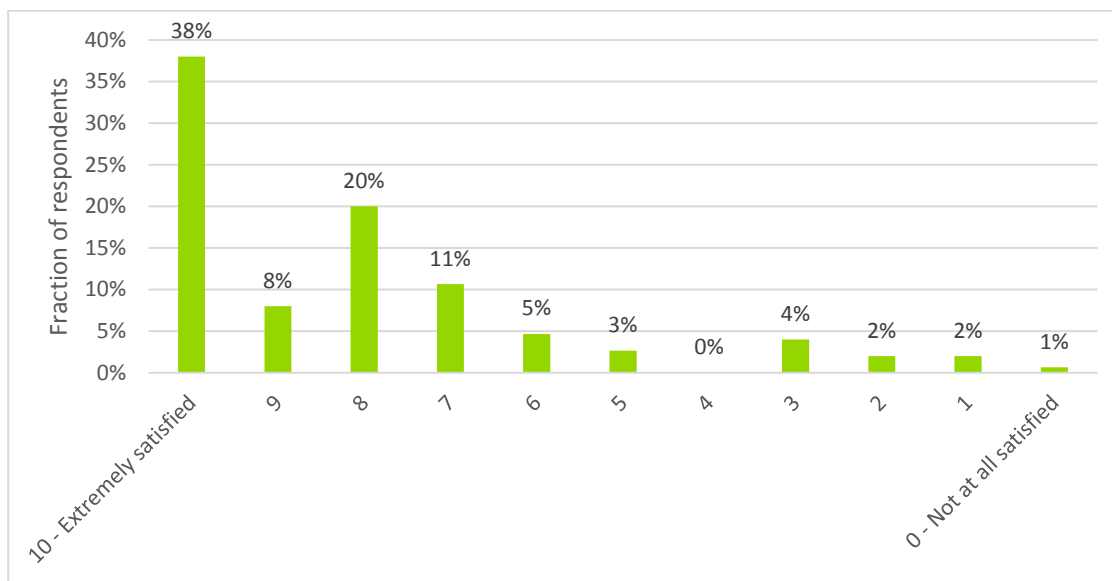
Navigant conducted phone surveys with 150 residential tenants to assess program satisfaction. The surveys contained a number of questions to assess satisfaction with program participation, satisfaction



with new equipment, as well as questions to assess measure baseline and any measures removed by the tenant after participation.

Customer satisfaction with the program is high. On a scale of 0 to 10, where 0 indicates “not satisfied at all” and 10 indicates “extremely satisfied,” two-thirds of customers rated satisfaction with the program as an 8-10 as shown in Figure 4. Participants who ranked their overall satisfaction low did so because they disliked the products or did not experience any energy savings. This chart includes data from both DEP and DEC territories as there were no significant satisfaction differences.

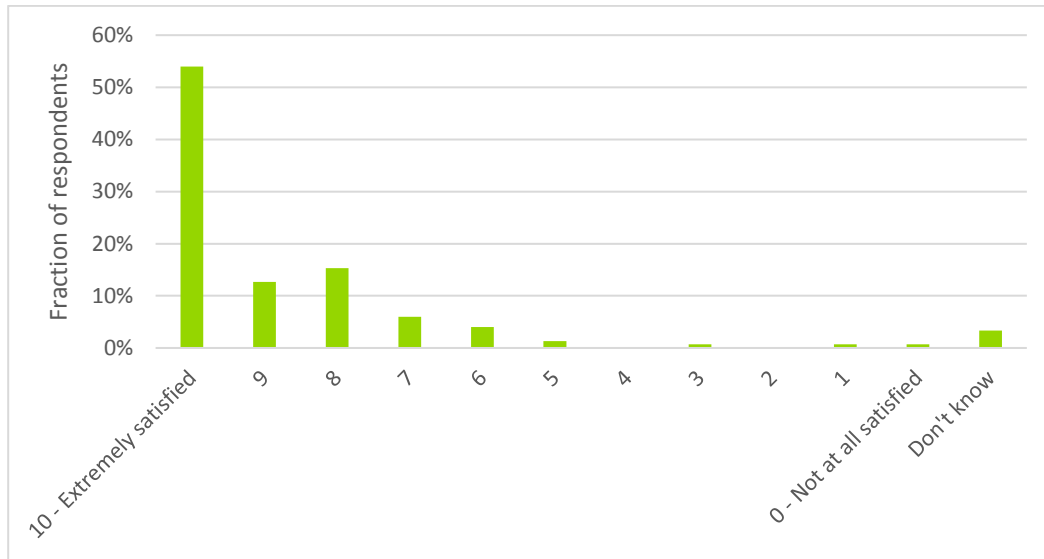
Figure 4. Tenant Satisfaction with Overall Program Experience (n=150)



Source: Navigant analysis

Customer satisfaction with the contractor quality of work was also high, as shown by Figure 5.

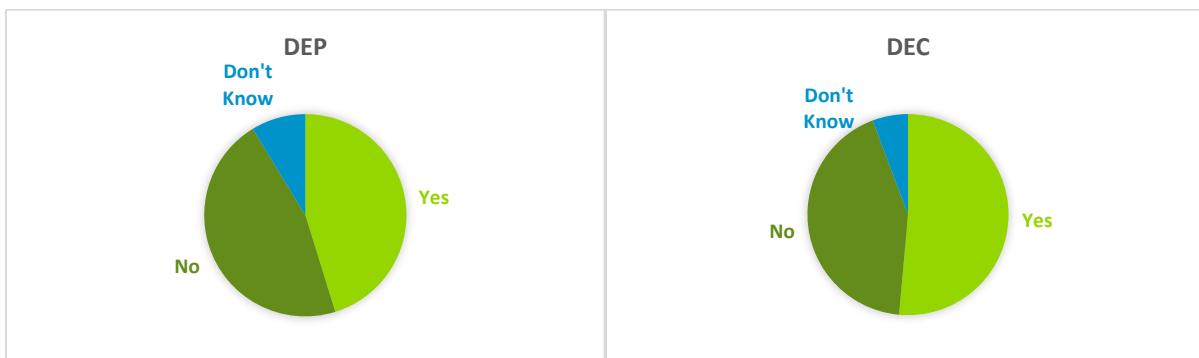
Figure 5. Tenant Satisfaction with Contractor's Quality of Work (n=150)



Source: Navigant analysis

As shown in Figure 6, about half of participants noticed a decrease in their energy bills after the new measures were installed.

Figure 6. Participants Who Noticed a Decrease in Their Energy Bill After Installing Program Measures (n=150)

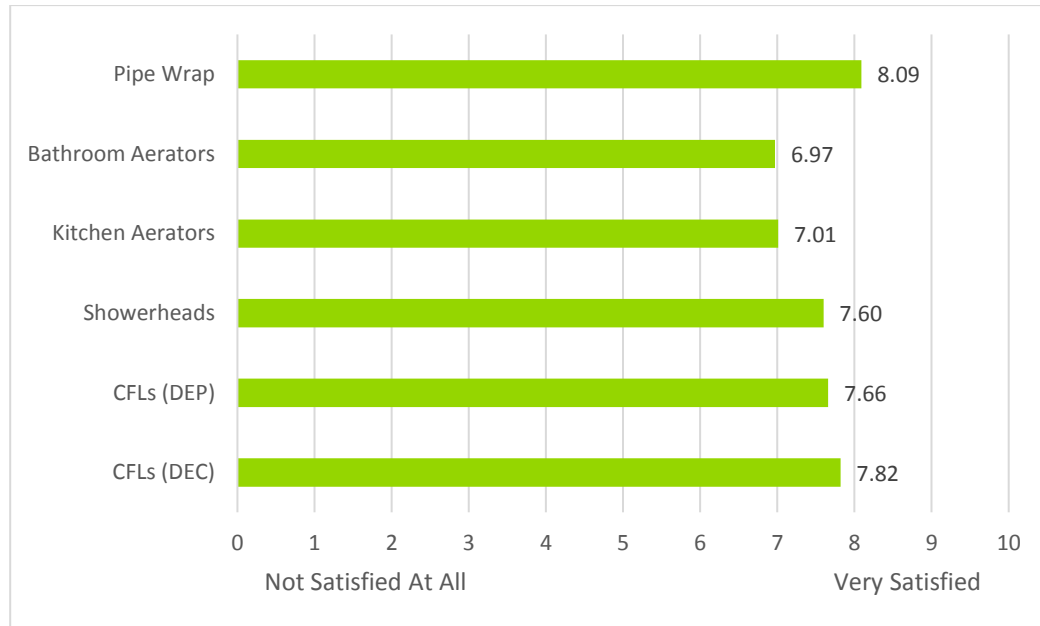


Source: Navigant analysis

While a majority of participants were satisfied with the new measures, some were not. Navigant asked the participants to rate their satisfaction for each measure installed at their home. Average satisfaction ratings ranged from as high as 8.09 out of 10 for Pipe Wrap, to as low as 6.97 out of 10 for bathroom faucet aerators as shown in Figure 7.



Figure 7. Tenant Satisfaction Rating for Each Measure (n=150)

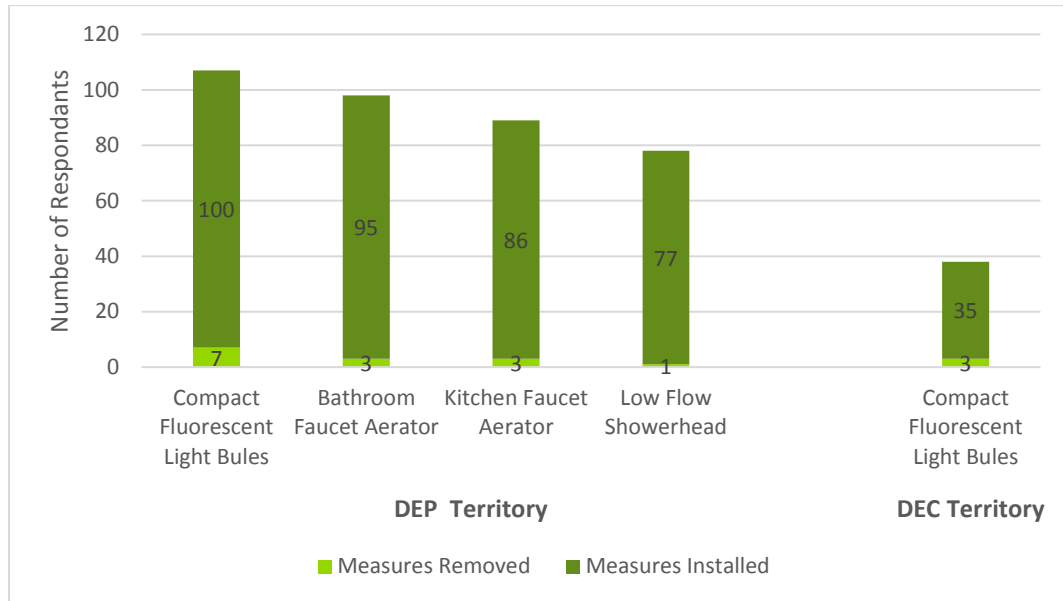


Source: Navigant analysis

A small percentage of tenants removed the installed measure as shown in Figure 8. In the DEC territory, 100 percent of the CFLs removed by tenants were bulbs that had burned out. In the DEP territory, 57 percent of the CFLs removed by tenants were due to burnout, and the remainder were removed due to poor product quality. Participants indicated they removed bathroom faucet aerators because of poor water pressure. Showerheads and kitchen faucet aerators were removed because of leakage or excess water spray.



Figure 8. Participants Who Removed Any Installed Measures



Source: Navigant analysis

6.5.1.1 Participant Suggestions

Navigant also included a question in the tenant satisfaction survey that allowed respondents to offer suggestions for improving the program. One-fourth of the respondents offered suggestions, which were as follows:

- Several respondents asked for a better quality of equipment, including the quality of CFLs, showerheads, and aerators
- Several participants asked for better notification of installation date and time
- Two participants requested LEDs instead of CFLs
- One respondent requested offering motion sensors



7. SUMMARY FORM

Multifamily Energy Efficiency Program

Completed EMV Fact Sheet

Description of program

Duke Energy's Multifamily Energy Efficiency Program provides energy efficient equipment to multifamily housing properties at no cost to the property managers or tenant end-users. The program is delivered through coordination with property managers and owners. Tenants are provided with notice and informational materials to inform them of the program and potential for reduction in their energy bills. Typically, measures are installed directly by the implementation contractor rather than tenants or onsite maintenance staff.

The program consists of lighting and water measures.

- **Lighting measures:** Compact fluorescent light (CFL) bulbs installed in permanent fixtures
- **Water measures:** Bathroom and kitchen faucet aerators, water-saving showerheads, hot water pipe wrap

Date:	June 27, 2017
Region:	Duke Energy Progress Duke Energy Carolinas
Evaluation Period	DEP 1/1/15 – 2/29/16 DEC 1/1/14 – 2/29/16
Annual kWh Savings	DEP 19,938,742 DEC 4,806,786
Per Participant kWh Savings	DEP 753 DEC 219
Net-to-Gross Ratio	0.94

Evaluation Methods

The evaluation team used engineering analysis and onsite field inspections as the primary basis for estimating program impacts. Additionally, telephone surveys were conducted with tenants and multifamily housing units to assess customer satisfaction and spillover. Detailed interviews were conducted with property managers to assess their decision-making process and ultimately to estimate a net-to-gross ratio.

Impact Evaluation Details

- **Field inspections were conducted at 123 housing units.** The evaluation team inspected program equipment at 123 housing units to assess measure quantities and characteristics to be compared with the program tracking database.
- **In-Service rates (ISRs) varied by equipment type.** The evaluation team found ISRs ranging from 85% for CFLs to 95% for low flow showerheads.
- **Participants achieved an average of 753 kWh of energy savings per year in DEP, and 219 kWh in DEC.** The evaluation for DEC only included lighting measures, whereas the evaluation for DEP included lighting and water measures. Therefore, the two should not be compared directly.
- **The type of lamp removed during retrofit that was most commonly reported by participants was 60W incandescents.** Of the tenants who could recall what type of lamps were removed during lighting retrofits, the majority reported 60W incandescents. The evaluation team believes that evaluation periods covering dates beyond the end of this cycle will include a lower baseline wattage for retrofitted lamps.



8. CONCLUSIONS AND RECOMMENDATIONS

Navigant's findings in this report suggest that Duke Energy's Multifamily Energy Efficiency Program is being delivered and tracked effectively in the DEC and DEP jurisdiction. Customer satisfaction is generally high, and the program measure installations appear to be tracked appropriately. Navigant presents the following list of recommendations that may help improve program delivery and impacts:

1. **Navigant recommends that Duke Energy should adopt the per-unit energy and demand impacts from this evaluation and use them going forward.** The engineering analysis and data collection described in this report provide support for updating the estimated impacts for each program measure. Duke Energy should consider additional research to investigate the baseline for CFLs for future evaluation cycles.
2. **Navigant recommends that no more than the first three feet of cold water inlet pipes be insulated for the water heater pipe wrap measure.** The U.S. Department of Energy recommends only insulating the first three feet of cold water inlet pipes. Beyond that, savings are likely negligible. During field verification, Navigant found that over half of the reported water heater pipe wrap was installed on cold water pipes (with just under 10 percent of those installations greater than three feet on the cold water heater pipes).
3. **Duke Energy should consider adding LEDs to the program.** Because of EISA, the baseline for the 13 watt CFL measure will eventually reach 40 watts instead of 60 watts. This will diminish the cost-effectiveness of program CFLs. LED options may provide increased savings and improved customer satisfaction.



9. MEASURE-LEVEL INPUTS FOR DUKE ENERGY ANALYTICS

Navigant used the findings from field verification, surveys, and review of Duke Energy's deemed savings to estimate an updated set of deemed savings for Duke Energy to use for tracking program activity. Table 27 provides the measure-level inputs that can be used by Duke Energy Analytics for estimates of future program savings. Impacts for water measures apply to the DEP jurisdiction only, whereas impacts from CFLs apply to both DEP and DEC.

Table 27. Gross Measure-Level Impacts

Measure	Annual Energy Savings Per Unit (kWh)	Annual Summer Coincident Demand Savings Per Unit (kW) ¹	Annual Winter Coincident Demand Savings Per Unit (kW) ²
Faucet Aerators MF Direct 0.5 GPM - bath	55.99	0.007	0.006
Faucet Aerators MF Direct 1.0 GPM - bath	39.52	0.005	0.005
Faucet Aerators MF Direct 1.0 GPM - kitchen	86.40	0.011	0.010
Faucet Aerators MF DIY 0.5 GPM - bath	45.46	0.006	0.005
Faucet Aerators MF DIY 1.0 GPM - bath	32.09	0.004	0.004
Faucet Aerators MF DIY 1.0 GPM - kitchen	68.98	0.009	0.008
LF Showerhead MF Direct 0.5 GPM	473.56	0.039	0.153
LF Showerhead MF Direct 1.0 GPM	355.17	0.029	0.115
LF Showerhead MF Direct 1.5 GPM	236.78	0.019	0.077
LF Showerhead MF DIY 0.5 GPM	374.70	0.031	0.121
LF Showerhead MF DIY 1.0 GPM	281.03	0.023	0.091
LF Showerhead MF DIY 1.5 GPM	187.35	0.015	0.061
Pipe Wrap MF Direct	67.03	0.008	0.008
Pipe Wrap MF DIY	54.08	0.006	0.006
13W CFLs	26.80	0.004	0.005

1. The summer coincident period for DEP and DEC is defined as weekdays in July, hour ending 17.

2. The winter coincident period for DEP and DEC is defined as weekdays in January, hour ending 8.



APPENDIX A. DETAILED SURVEY RESULTS

This appendix contains additional results from the property manager interviews and tenant surveys. It is meant as a supplement to other sections of the report.

A.1 Property Manager Interviews

Navigant conducted in-depth interviews with 21 property managers. As shown in Table 25, the sample of 21 property managers represented 39 properties. This section presents details of the interviews. The responses to each question shown are paraphrased to maintain confidentiality and summarize the key points.

Table 28. How did you learn about the Duke Energy Multifamily Energy Efficiency Program?

Respondent(s)	Response
1,2,5,7,10-12,14,16-18,21	Duke Energy online, mail or email
3,4,6,9	Corporate company mandated
8,13,15,19,20	Approached by a program representative

Source: Navigant analysis

Table 29. What were the primary reasons to participate in the program?

Respondent(s)	Response
1,7,10,	Energy Efficiency
3,4,14	Corporate mandated
5,8,9,12,13,15,18,21	To save money
2,6,11,16,17,19,20	To savings water cost for tenants

Source: Navigant analysis

Table 30. On a scale of 0 to 10, with 0 being “not satisfied at all” and 10 being “extremely satisfied”, how satisfied are you with your overall program experience?

Respondent(s)	Response
1-4,7,9-12,14,18,20	10
5,20	9
13,16,17,19	8
8	7
6	5

Source: Navigant analysis



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Table 31. On a scale of 0 to 10, with 0 being “not satisfied at all” and 10 being “extremely satisfied”, how satisfied are you with the tenant notification and program materials?

Respondent(s)	Response
3,4,6,10-12,14,16,18,21	10
1,2,5,7,15,20	9
8,9,13	8
19	7
17	5

Source: Navigant analysis

Table 32. On a scale of 0 to 10, with 0 being “not satisfied at all” and 10 being “extremely satisfied”, how satisfied would you say your tenants are with the new energy efficient equipment?

Respondent(s)	Response
1,3,12	10
2,10,14	9
5-7,9,11,16,17,21	8 – because some of the tenants prefer the incandescent light bulbs because of look and color, but most really like the CFLs
8,15,19	7 – the kitchen aerators and showerheads are leaking and breaking, requiring equipment repairs
4,13,20	6
18	5 – water measures cut down water pressure noticeably

Source: Navigant analysis

Table 33. On a scale of 0 to 10, with 0 being “not likely at all” and 10 being “very likely”, how likely are you to recommend the Multifamily Energy Efficiency Program to other property managers?

Respondent(s)	Response
1,7,9-12,14, 16,18,20,21	10
2,15,19	9
4,5	8
3,6,8,13,17,	7

Source: Navigant analysis

Table 34. Prior to participating in the program, had you considered installing the same energy efficient equipment at your facility?

Respondent(s)	Response
1-6,8,10-15,19	No
7, 16-18,20	Yes

9	Yes – for lighting measures, not the water measures
21	Yes, they considered installing CFLs and the water measures to save on energy bills

Source: Navigant analysis

Table 35. Did your experience with the program influence you to incorporate any additional energy efficiency equipment for which you did not receive a Duke Energy program rebate?

Respondent(s)	Response
1-4,6,9,11-20	No
5	Yes, installing LED
7	Yes, remodeling apartments
8	Yes, installed more energy efficiency exterior lighting
21	Yes, insulation blankets on water heaters, insulation on attic, and caulked windows at multiple properties

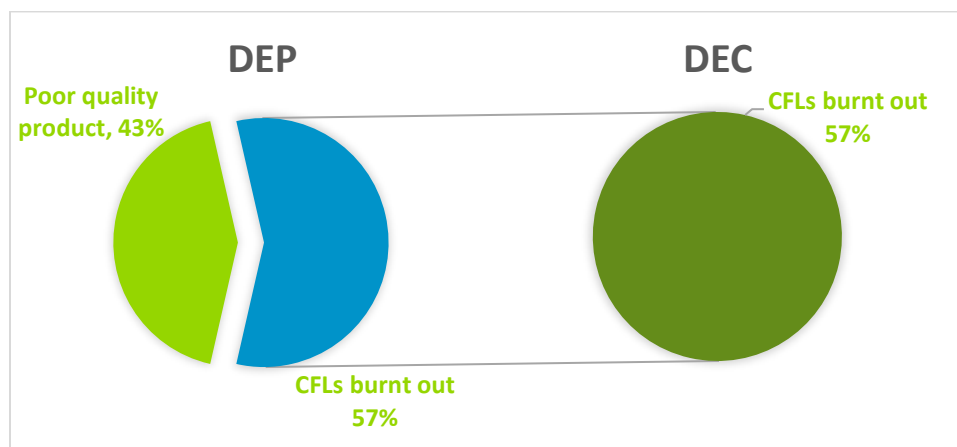
Source: Navigant analysis

A.2 Tenant Satisfaction Surveys

Satisfaction surveys were conducted with 150 program participants. Many of the results are presented in Section 6.5 of the main report, and this section serves as a supplement.

Figure 9 shows the reasons why tenants removed CFLs, the most common being burnout. For water measures, the most common reason for removal was low water pressure and leakage, although fewer measures had been removed.

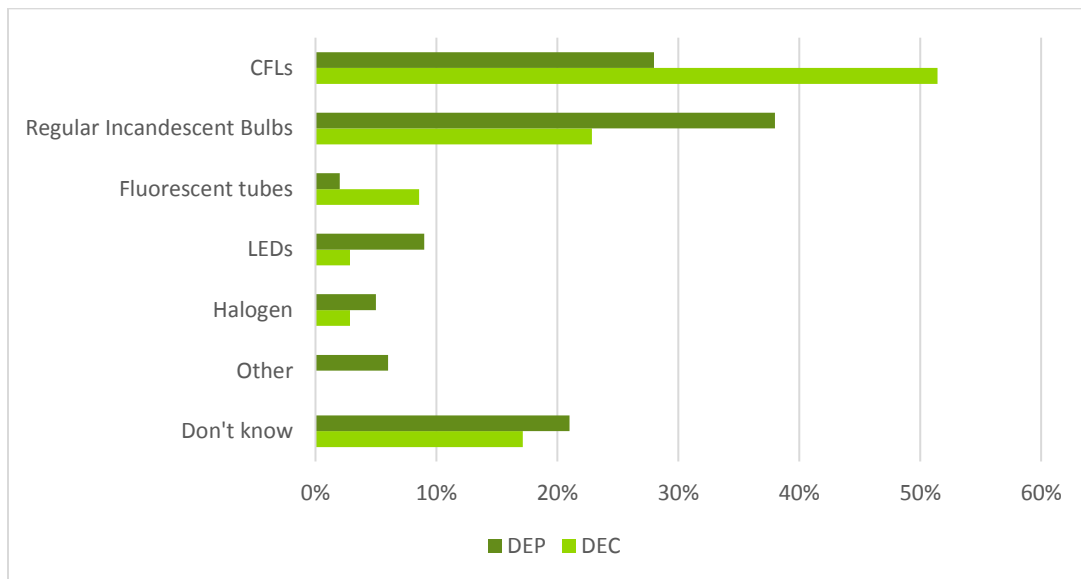
Figure 9. Reasons Why Tenants Removed CFLs (DEP = 7; DEC=3)



Source: Navigant analysis

Figure 10 shows the types of light bulbs that tenants reported as being installed in the non-retrofitted fixtures in their homes. For the DEC territory, an important supplement to this figure is that just under 90 percent of tenants reported that program CFLs were installed in the fixtures used most in their homes, which demonstrates that the program is effective in reaching the fixtures with greatest savings potential. For the DEP territory, just under 50% of tenants reported that CFLs were installed in fixtures that are used most in the home. Additionally, for the DEP jurisdiction 60 percent of tenants reported that they were very likely to install CFLs in their home in the future; for the DEC jurisdiction 77 percent of tenants indicated they were very likely to purchase CFLs in the future.

Figure 10. Type of Bulbs Found in Non-Retrofitted Fixtures



Source: Navigant analysis

As noted earlier, overall tenant satisfaction with the program was very high for DEP and DEC jurisdictions, with an average rating of 8.05 on a scale of 0 to 10 with 10 as very satisfied. However, ten of the 150 tenants reported a satisfaction of five or less with the program for the following reasons:

- No money savings (n=7)
- Dislike products (n=1)
- Mandated program participation by property management (n=1)

Tenants also reported a few suggestions for improving the program:

- Improve the kitchen faucet aerator (n=4)
- Improve the quality of products (n=3)
- Improve the quality of CFLs (n=3)
- Provide LEDs instead of CFLs (n=2)
- Provide participants a discount (n=1)
- Offer motion sensors (n=1)